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(DE95000042)

Tampa Electric Company Polk Power Station Unit No. 1

Annual Report
January - December 1993

August 1994

Work Performed Under Cooperative Agreement No.: DE-FC21-91MC27363

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Tampa Electric Company
Tampa, Florida

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P. O. Box 111
Tampa, Florida 33601

August 1994

TAMPA ELECTRIC COMPANY

DOE IGCC DEMONSTRATION PROJECT

POLK POWER STATION - UNIT 1

1993 TECHNICAL PROGRESS REPORT

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EXECUTIVE SUMMARY:

This report satisfies the requirements of Cooperative Agreement DE-FC21-91MC27363, novated as of March 5, 1992, to provide an annual update report on the year's activities associated with Tampa Electric Company's 250MW IGCC demonstration project for the year 1993.

I. Project Description:

Tampa Electric Company's Polk Power Station Unit 1 (PPS-1) Integrated Gasification Combined Cycle (IGCC) demonstration project will use a Texaco pressurized, oxygen-blown, entrained-flow coal gasifier to convert approximately 2000 tons per day of coal (dry basis) coupled with a combined cycle power block to produce a net 250 MW electrical power output. Coal is slurried in water, combined with 95% pure oxygen from an air separation unit, and sent to the gasifier to produce a high temperature, high pressure, medium-BTU syngas with a heat content of about 250 BTU/scf (LHV). The syngas then flows through a high temperature heat recovery unit which cools the syngas prior to its entering the cleanup systems. Molten coal ash flows from the bottom of the high temperature heat recovery unit into a water-filled quench where it solidifies into a marketable slag by-product.

Approximately 50% of the raw, hot syngas is cooled to 900 degrees Fahrenheit and passed through a moving bed of zinc-based sorbent which removes sulfur containing compounds from the syngas. PPS-1 will be the first unit in the world to demonstrate this advanced metal oxide hot gas desulfurization technology at a commercial scale.

The remaining portion of the raw, hot syngas is cooled to 400 degrees Fahrenheit for conventional acid gas removal. This portion of the plant is capable of processing 100% of the raw syngas.

Sulfur-bearing compounds from both cleanup systems are sent to a conventional sulfuric acid plant to produce a marketable, high-purity sulfuric acid by-product.

The cleaned medium-BTU syngas from these processes is routed to the combined cycle power generation system where it is mixed with air and burned in the combustion section of the combustion turbine. Nitrogen from the air separation unit at 98% purity is simultaneously injected into the combustion section to reduce the formation of nitrous oxides and to enhance mass flow through the combustion turbine for power augmentation. This combination results in the generation of about 192 MW of electricity from the combustion turbine-generator.

Heat is extracted from the expanded exhaust gases in a heat recovery steam generator (HRSG) to produce steam at three pressure levels for use throughout the integrated process. The majority of this steam, at high pressure, together with high pressure steam generated in the gasification process drives a steam turbine-generator set to produce additional electrical output of about 122 MW. Internal plant power consumption is approximately 62 MW, resulting a net power output from the integrated unit of 250MW.

A highly modular, microprocessor-based distributed control system (DCS) is being developed to provide continuous and sequential control for most of the equipment on PPS-1. This network will be designed to communicate with other key plant control units like the combustion turbine and steam turbine control systems and the gasification emergency shutdown system. The DCS is an important part of the IGCC facility in that it provides the control link that will integrate these complex processes.

The Electric Power Research Institute (EPRI) is an active partner in the Polk IGCC Project in that it is providing a full-time technical advisor to the Project with extensive gasification experience, and is funding the development and utilization of a valuable diagnostic tool for this project, a dynamic simulator. This tool will be used to simulate various operating modes of plant equipment, including upset conditions which are likely to occur within the complex systems which comprise the IGCC facility, and will also be a valuable tool during the training program for plant operators and technical personnel. The EPRI technical advisor also serves as an important member of the Project's Technical Advisory Committee (TAC) which will be described in more detail in the Project Management section of this report.

II. PROJECT HIGHLIGHTS

This section describes in condensed form some of the key features of this Project which make it unique and contribute to the performance advantages associated with IGCC as compared to conventional coal-fired power generation technology.

The Polk IGCC Demonstration Project is co-funded by the U.S. Department of Energy (DOE) as a part of their Clean Coal Technology (CCT) Program, Round III, with specific emphasis on demonstration of the commercial-scale integration of the gasification system with the power island, and on the development and demonstration of a commercially and technically viable hot gas cleanup system.

The PPS-1 IGCC facility is based on a fully integrated concept which utilizes virtually all of the oxygen and nitrogen produced by the ASU to meet gasifier oxygen demand and diluent nitrogen requirements for the combustion turbine.

The syngas cooling systems generate supplemental steam and make effective use of available heat within the cycle, resulting in significant overall plant efficiency gains.

The demonstration hot gas cleanup system will result in improvements to heat rate as well as reduced power consumption as compared to the conventional process of cold gas cleanup using acid gas removal technology.

By-products are extracted as marketable entities, primarily as slag and sulfuric acid.

Site selection for this plant was made based upon recommendations made by a uniquely conceived Site Selection Task Force comprised of prominent environmentalists, educators, and business and community leaders. Environmental impact was a primary driver in the choice of allowable sites for the plant. Consequently, the plant will be located in Polk County, Florida on property largely having been previously mined for phosphate rock. Substantial work in the areas of mine reclamation, wetlands and uplands restoration and establishment of a wildlife corridor will be completed in conjunction with the development of the IGCC facility.

III. ENVIRONMENTAL / PERMITTING

The following significant events related to the Polk IGCC Project's Environmental and Permitting requirements occurred in 1993.

January 26: The Florida Governor and Cabinet, sitting as the Siting Board, issued an order stating that the PPS Project was consistent and in compliance with all applicable land use plans and zoning ordinances.

March 5: DOE accepted the submitted Environmental Impact Volume as a final document.

April: The Florida Department of Natural Resources (FDNR) approved the Project's Conceptual Mine Reclamation Plan (CMRP). The CMRP process has since been rolled into the Site Certification Application (SCA) process due to the merger of the FDNR and the Florida Department of Environmental Regulation (FDER) into the Florida Department of Environmental Protection (FDEP).

May 10: The FDEP deemed the Project's SCA sufficient.

June 28: The Preliminary Draft Environmental Impact Statement (PDEIS) for the Project was issued for review.

July 30: Individual Agency Reports were submitted to FDEP on or before this date by:
- Polk County
- Southwest Florida Water Management District
- Florida Department of Transportation
- Florida Department of Community Affairs
- Florida Game and Freshwater Fish Commission

August 13: FDEP issued its composite Agency Report on the Project.

August 25: EPA issued the NPDES "Stormwater General Permit Coverage Notice".

August 25: EPA forwarded comments to the PDEIS to TEC's third party environmental contractor.

October 13: Site Certification Hearings held.

October 29: Land Use Hearing held.

November 23: State Hearing Officer issued order recommending approval of Site Certification.

IV. MAJOR CONTRACTS AWARDED

A. Turnkey Air Separation Unit: The contract for engineering, supply and erection of the air separation unit (ASU) for PPS-1, dated April 14, 1993, was awarded to Air Products & Chemicals, Inc. The ASU is designed to produce 2020 tons per day (TPD) of 95mol% pure oxygen, 1985 TPD at 575 psig and 35 TPD at 50 psig, and 6400 TPD of nitrogen, 6000 TPD at 255 psig and 98mol% purity for syngas diluent and 400 TPD at high pressure and 99.99mol% purity for sootblowing.

B. Detailed Professional Engineering and Technical Services: The contract for completing the final design of the Project (less portions performed by TEC's separate contractors), for acting as TEC's procurement agent for the Project, and for managing and coordinating the Technical Advisory Committee, dated April 22, 1993, was awarded to Bechtel Power Corporation.

C. Hot Gas Clean Up System Preliminary Design: The contract for preliminary definition of the hot gas clean up (HGCU) system design, dated June 2, 1993, was awarded to General Electric Environmental Services, Inc. (GEESI). The HGCU system is designed to process 50% of syngas output from gasification. GEESI will provide estimates for detailed design, procurement support and start-up support activities at a later date.

D. Engineered Equipment Package for Radiant Syngas Cooling System: The contract for the engineering, design, manufacture, preparation for shipment and on-site delivery of the radiant syngas cooling (RSC) system, dated June 4, 1993, was awarded to MAN Gutehoffnungshutte AG (MAN GHH). The RSC system is designed to cool the hot syngas exiting the gasifier, generate high pressure steam to be sent to the HRSG, and remove coal ash from the syngas stream in the form of slag.

E. Engineered Equipment Package for Convective Syngas Cooling System: The contract for the engineering, design, manufacture, preparation for shipment and on-site delivery of the convective syngas cooling (CSC) system, dated June 4, 1993, was awarded to L & C Steinmuller GmbH. The CSC system is designed to cool the raw syngas exiting the RSC system and exchange the heat energy with portions of clean syngas and nitrogen from the remainder of the integrated process.

F. Construction Management Services: The contract for assessment of various construction options during the preconstruction period and for the monitoring, coordination and general direction of all construction contractors for the Project, dated June 24, 1993, was awarded to Bechtel Power Corporation.

G. Distributed Control System: The contract for the Distributed Control System as a complete Engineered Equipment Package, dated October 8, 1993, was awarded to Bailey Controls Company. The DCS will be used to integrate all major control systems for the IGCC facility, and is an important addition to this Project due to the control system complexities involved in this process.

H. Power Plant Site Purchase Agreements: The agreements for the purchase of the primary properties to be used for Polk Power Station, including surrounding uplands, wetlands and wildlife corridor, were closed in December of 1993 with Freeport-McMoran Resource Partners and American Cyanamid Company. The three (3) tracts represented above include 4347 acres.

V. PROCESS DESCRIPTION

A. Coal Handling, Grinding, and Slurry Preparation

Coal is delivered to the site from a coal transloading facility at Tampa Electric Company's Big Bend Station. The coal will be delivered in covered, bottom-dump trucks with a 28-ton payload. A total of 80 to 100 trucks per day will be required at design rate. On the site, the trucks will off-load in an enclosed unloading structure into an above-grade unloading hopper. Dust suppression sprays are provided at the top of the hopper to control dust emissions. Belt feeders will transfer coal from the hopper outlets onto an enclosed unloading conveyor.

The unloading conveyor will transport coal from the unloading structure up and into one of the two storage silos. A diverter gate and a silo feed conveyor provide the set-up to feed the second, adjacent silo. A dust collection system is provided at the top of the silos to collect dust at the conveyor/feeder/silo transfer points.

Coal is conveyed from the coal silos and fed to the grinding mill with recycled process water and makeup water from the plant service water supply system. The grinding mill may also be fed fine coal recovered by the dust collection system. Ammonia may be added to the mill for pH adjustment, if necessary. The pH of the slurry will be maintained between 6 and 8 to minimize corrosion in the carbon steel equipment. A slurry additive for reducing viscosity will also be pumped continuously to the grinding mill.

The grinding mill reduces the feed coal to the design particle size distribution. The mill is a conventional rod-type system with an overflow discharge of the slurry. Slurry discharged from the grinding mill will pass through a trommel screen and over a vibrating screen to remove any oversized particles before entering the slurry tank. Oversized particles will be recycled to the grinding mill.

A below-grade grinding sump is located centrally within the coal grinding and slurry preparation area to handle and collect any slurry drains or spills in the area. Materials collected in the sump will be routed to the recycle tank for reuse in the process.

In order to minimize groundwater withdrawal and use, water for the slurry preparation system is provided from several sources. It is provided primarily by the moisture contents of the feedstock coal, the recycled feed and the grinding sump water. Additional makeup water to the slurry system is provided from the plant service water system. Through the collection and recycling process, there will be no water discharges from the coal grinding and slurry preparation system. All water from the system is fed to the gasifier in the coal slurry.

Potential particulate matter air emissions from the coal storage bin, grinding mill, and rod mill overflow discharge will primarily be controlled by the wet nature of these subsystems and by the use of enclosures for the subsystems with vents through fabric filters or baghouses. The slurry tank vents are equipped with carbon canisters for absorption of potential H_2S or ammonia (NH_3) emissions.

B. Gasifier System

The IGCC unit uses the Texaco oxygen-blown, entrained-flow, single-train gasification system to produce syngas for combustion in the advanced combustion turbine (CT).

Coal slurry from the slurry feed tank and oxygen from the air separation unit are fed to the gasifier and sent to the process burner. The gasifier is a refractory lined vessel capable of withstanding high temperatures and pressures. The coal slurry and oxygen react in the gasifier to produce syngas at high temperature. The syngas consists primarily of hydrogen, CO, water vapor, and CO_2, with small amounts of H_2S, COS, methane, argon, and nitrogen. Coal ash and unconverted carbon form a liquid melt called slag in the gasifier.

Hot syngas and slag flow downward in the gasifier into the radiant syngas cooler, which is a high pressure steam generator equipped with a water wall to protect the vessel shell. Heat will be transferred primarily by radiation from the hot syngas to the boiler feed water circulating in the water wall. High pressure steam produced in this boiler is routed to the heat recovery steam generator (HRSG) in the power block area which will supplement the heat input from the CT to the HRSG and increase the efficiency of the generating unit.

The syngas passes over the surface of a pool of water at the bottom of the radiant syngas cooler and exits the vessel. The raw syngas is sent to the convective coolers and then to the low temperature syngas cooling system in the CGCU system for further heat recovery and to the demonstration HGCU system. The slag drops into the water pool and is fed to the lockhopper from the radiant syngas cooler sump.

The black water which flows out with the slag from the bottom of the radiant syngas cooler will be separated from the slag and recycled after processing in the dewatering system.

C. Cold Gas Clean Up (CGCU)

The raw, hot syngas from the gasifier is routed to the separate conventional CGCU and demonstration HGCU systems for appropriate treatment. The CGCU system is designed to treat 100 percent of the syngas flow for the unit, while the HGCU system will be capable of treating approximately 50% of the syngas. The CGCU system is described in the following paragraphs, and description of the HGCU system is provided starting in the next subsection.

The initial treatment process for the raw syngas within the CGCU system involves the syngas scrubbing and cooling systems.

The raw, hot syngas from the gasifier will contain entrained solids or fine slag particles which must be removed to produce the clean syngas fuel. Also, the raw hot syngas needs to be cooled in order to be effectively cleaned in the acid gas removal unit.

The raw, hot syngas from the gasifier is first cooled in the high temperature syngas cooling system, then sent to the syngas scrubbers where entrained solids are removed. The syngas is then routed to the low temperature gas cooling section, where the syngas is cooled by recovering its waste heat by generating steam and preheating boiler feedwater. The syngas is further cooled with cooling water, which will condense out much of the water from the syngas prior to its routing to the acid gas removal system.

The syngas scrubber bottoms are routed to the black water handling system. All the black water from the gasification and syngas cleanup processes will be collected, processed, recycled to the extent possible, and contained within the processes. The solids that were not removed in the radiant syngas cooler sump will be separated from the system as fines. There will be no liquid discharges of these process waters to other systems or to the cooling reservoir.

The effluent from the black water handling system will be concentrated and crystallized into a solid consisting primarily of salt called brine which will be stored in a lined landfill on the site with an appropriately designed leachate collection system. The water separated from the salts will be recycled for slurrying coal feed.

After removal of the entrained solids, the gaseous sulfur compounds (H_2S and COS) are to be removed from the syngas prior to firing in the advanced CT unit to control potential SO_2 air emissions.

In the acid gas removal unit, the cooled syngas will first be water-washed in the water wash column. Wash water is pumped to the column to remove contaminants which would potentially degrade the amine from the syngas. The wash water from the column is sent to the NH_3 water stripper.

The washed syngas will then flow to the amine absorber where the syngas will be in contact with circulating amine. Acting as a weak base, the amine will absorb acid gases such as H_2S by chemical reaction. The purified syngas will flow through a knockout drum to remove entrained amine. The recovered liquid will be returned to the amine stripper.

The rich amine will be stripped of the acid gas in the amine stripper by steam generated in the stripper reboiler. The acid gas overhead will be partially condensed by the reflux condenser and collected in the reflux accumulator. The acid gas, primarily H_2S and CO_2, from the reflux accumulator will go to the sulfuric acid plant and the condensed liquid reflux will be returned to the amine stripper.

D. Hot Gas Clean Up (HGCU)

For the system demonstration, the unit is designed to have the capacity of handling 50% of the hot, raw syngas from the gasifier for cleanup prior to firing in the combustion turbine. The key process steps for the system follow:

Entrained fine particles in the hot syngas will be removed in the primary cyclone first and recycled to the black water handling system. The exiting gas is injected with sodium bicarbonate and enters a secondary cyclone where the halogen compounds in the gas are chemically absorbed. The collected solids from the cyclone will be sent to the onsite brine storage area and the syngas flow to an absorber.

A large fraction of any remaining particulate matter entering the absorber will be captured by the zinc oxide sorbent bed, reducing particle concentration to below 30 ppm. A small amount of sorbent fines will be entrained from the absorber and collected in a high efficiency barrier filter. The barrier filter will practically eliminate all fines larger than 5 microns. 99.5% of particulate matter will be removed. The solids from the barrier filter will be sent offsite for disposal. Larger fines will be sieved on screens at the regenerator sorbent outlet. Fugitive fines from the screens will be collected in a small, low temperature bag filter. The sorbent fines from both collection points will be reclaimed offsite.

The absorber is an intermittently moving bed reactor. The sulfur-containing syngas from the cyclones will enter the absorber through a gas manifold at its bottom and flow upward countercurrent to the moving bed of sorbent pellets. The sulfur compounds, mainly H_2S, in the syngas react with the zinc oxide sorbent to form zinc sulfide. The syngas leaving the absorber is expected to contain less than 30 ppmv of H_2S and COS.

To maintain low H2S outlet concentrations, the absorber bed will be periodically moved. A timed signal or an H_2S breakthrough control signal will activate solids flow from the bottom of the absorber into the absorber's outlet lockhopper, causing the bed and the reaction zone to move downward by gravity. The displaced sulfided sorbent will be replaced by regenerated sorbent from the absorber's inlet lockhopper.

The ability to regenerate and recycle the sorbent is essential for economically viable hot syngas desulfurization. The regeneration with oxygen is a highly exothermic oxidation process which requires careful temperature control. Too high a temperature will sinter and destroy the sorbent structure and reduce its ability to react with sulfur in consecutive absorption steps. Low temperature will result in sulfate formation and a loss of reactive sorbent returnihng to the desulfurization process in the absorber.

Sulfided sorbent is fed from the absorber's outlet lockhopper to the top of the regenerator where oxidation of the sulfided sorbent occurs. The sorbent moves down the regenerator in cocurrent flow with the regeneration gas. The air to recycle gas ratio is controlled to limit the gas temperature.

The final step of regeneration is accomplished at the lower stage of the regenerator where nitrogen flows countercurrent to the sorbent. This stream will cool the sorbent to a temperature acceptable for downstream equipment, purge the SO_2 - rich offgas, and ensure complete regeneration without sulfate formation. The gas streams from the cocurrent and countercurrent flows mix to form the recycle gas stream.

The regeneration gas recycle system operates in a closed loop with dry air as an input and an SO_2 - rich offgas as a product output. The regeneration gas recycle loop is designed as an internal diluent that will reduce the oxygen concentration in the air to the desired levels and remove the heat of reaction without the use of externally provided diluents such as nitrogen. Using recycle rather than external inert diluent will also enrich the SO_2 concentration of the product stream.

The heat exchanger in the recycle loop is designed to control the temperature of the regenerator inlet streams. The steam generator will remove the heat generated during the regeneration reaction by cooling the recycle gas stream. The recycle compressor will operate at a sufficient suction temperature to avoid H_2SO_4 condensation and a regenerative gas heat exchanger will reheat the compressed gas for recycle to the regeneration process. The heat of combustion of the sulfur is transferred to the combined cycle power block through the steam generated prior to recycle compression of the recycle gas stream.

E. Combined Cycle Power Generation

Key components of the combined cycle power generation system are the CT-Generator, HRSG, and ST-Generator.

1. Combustion Turbine-Generator

The CT is a GE 7F, designed for low-NO_x emissions firing syngas, with low sulfur fuel oil for startup and backup. Rated output from the hydrogen-cooled generator when the CT is firing syngas is 192 MW.

The syngas is delivered to the combustion turbine via control valves on the syngas fuel control skid. Nitrogen is used as the diluent to reduce the formation of NO_x in the exhaust gas. The flow of nitrogen to the combustor is regulated by valves on the nitrogen control skid.

When operating on the fuel oil backup, demineralized water is used as a diluent to reduce the formation of NO_x in the exhaust gas. The flow of fuel oil and demineralized water is controlled by a separate skid, the fuel forwarding skid.

2. Heat Recovery Steam Generator

The heat recovery steam generator recovers the combustion turbine exhaust heat to produce steam for the generation of additional power in the steam turbine. The HRSG is a design of three-pressure level (HP,IP,LP), reheat (RH), and natural circulation.

The HP section heats boiler feed water (BFW) and generates superheated steam for feed to the HP steam turbine. It also provides HP economized BFW to the gasification area and receives HP saturated steam from gasification.

The RH section combines HP turbine exhaust with IP superheated steam and adds superheat to the mixture for feed to the IP steam turbine.

The IP section heats BFW and generates superheated steam to be mixed with cold reheat steam for feed to the RH section. The IP section also provides BFW and saturated steam to the gasification plant.

The LP section heats and deaerates BFW for the HP and IP systems and provides saturated steam and deaerated LP feedwater for export to the gasification plant.

3. Steam Turbine-Generator

The steam turbine-generator is a double flow reheat unit with low pressure crossover extraction and a hydrogen-cooled generator. The steam turbine-generator is designed specifically for highly efficient combined cycle operation with nominal turbine inlet conditions of approximately 1450 psig and 1000°F with 1000°F reheat inlet temperature. Rated capacity is 124.2 MW; rated speed is 3600 rpm. Expected output during normal operation is 122 MW.

The outlet from the last stage of the turbine is condensed by heat exchange with circulating water from the plant cooling water reservoir. Condensate from the steam turbine condenser will be returned to the HRSG/integral deaerator by way of the coal gasification facilities, where some condensate preheating occurs.

4. Condensate System

The condensate system operates in this combined cycle power plant to:

* Return condensed steam to the cycle by pumping condensate from the condenser hotwell to the deaerator.
* Condense the steam from the steam turbine gland seals and return the condensate to the cycle.
* Provide sources of condensate to various miscellaneous systems.
* Provide a dump to the condensate storage tank on a high hotwell level, and to provide condensate makeup to the condenser hotwell.

Condensate pump operation is required during combined cycle operation. One of the two 100 percent capacity condensate pumps is always in service during normal plant operation, while the other condensate pump is in the "auto" standby mode.

A hotwell dump line is connected from the condensate discharge line to the condensate storage tank for returning condensate in the event of a high level in the hotwell. Condensate supply to the hotwell is by way of vacuum drag under normal operation, and by the condensate make-up pump otherwise.

The condensate pumps also supply water to the:

- Steam Turbine Exhaust Hood Spray System
- Vacuum Pump Seals
- Condensate Receiver
- Condensate Return Unit
- Gland Seal Emergency Spray
- HRSG Chemical Injection Equipment
- Closed Cooling Water Head Tank
- Feedwater Pump Seals

5. Electrical Power Distribution System

For plant startup and periods when the plant is down, power is received at 230 KV and is backfed through the generator step-up transformers with the generator breakers in the open position. This provides power to the station 13.8 KV auxiliary transformers. The station 13.8 KV switchgear distributes power at 13.8 KV to the various plant loads including the power block 4160V and 480V auxiliary transformers. The 4160V switchgear provides power to the combustion turbine static starting system and to the 4160V motors.

During startup, power is back-fed through the CT generator step-up transformer or the steam turbine generator step-up transformer to power up the static starting unit. Once the combustion turbine is up to speed and self sustaining, the static starter is deenergized, and the generator can be synchronized to the 230 KV system by closing the 18 KV generator breaker. Similarly, when the steam turbine generator is up to speed, it can be synchronized to the 230 KV system by closing the appropriate 230 KV switchyard breakers first and then the steam turbine generator breaker.

Once the combustion turbine is started up and synchronized to the system, the combustion turbine can provide power to all of the station loads through the station 13.8 KV power distribution systems.

The 480V switchgear distributes power to the various 480V motors and motor control centers associated with the operation of the power generation system.

The power block 125 VDC requirements are provided from two batteries. One battery is dedicated to the combustion turbine and is contained in the packaged electrical and electronic control cab. Other 125 VDC loads associated with the power generation system are served from the station battery system.

Power will be generated at 18 KV by the combustion turbine generator and at 13.8 KV by the steam turbine generator.

Each generator is connected via iso-phase bus duct to its respective generator step-up transformer through an SF6 generator breaker and disconnect switch. Bus duct taps are provided for connection to the station auxiliary transformers.

F. Air Separation Unit

The Air Separation Unit uses ambient air to produce oxygen for use in the gasification system and sulfuric acid plant, and nitrogen which will be sent to the advanced CT.

Ambient air is filtered in a two-stage filter designed to remove particulate material. The first filter stage consists of a fixed panel filter; the second filter stage consists of removable elements, which are periodically replaced. The air will then be compressed in a multistage centrifugal compressor equipped with inter-cooling between stages and a condensate removal system.

The compressed air is cooled in an aftercooler and fed to the molecular sieve adsorbers. The molecular sieves will remove impurities, such as water vapor, CO_2, and some hydrocarbons from the air. The air is filtered once more in the dust filter to remove any entrained molecular sieve particles. Hot nitrogen is used for adsorbent regeneration. It is recovered and reused as CT diluent.

The air from the adsorbers is fed to the cold box where it is cooled against returning gaseous product streams in a primary heat exchanger (PHX). A small fraction of the air will be extracted from the PHX and expanded to provide refrigeration for the cryogenic process. The expanded air is then fed to the low pressure distillation column for separation.

The remaining air will exit the cold end of the PHX a few degrees above its dewpoint. The air is fed to the high pressure distillation column where it is separated into a gaseous nitrogen vapor and an oxygen-enriched liquid stream. The nitrogen vapor is condensed in the high pressure distillation column condenser against boiling liquid oxygen. The liquid nitrogen is used as reflux in the high and low pressure distillation columns.

Oxygen and nitrogen are produced in the low pressure distillation column. Heat from the condensing nitrogen vapor will provide reboiler action in the liquid oxygen pool at the bottom of the low pressure distillation column. The oxygen vapor will be warmed to near-ambient temperature in the PHX and fed to the oxygen compressor, where it will be compressed to the pressure required by the gasification unit.

Nitrogen vapor from the low pressure distillation column will be warmed to near-ambient temperature in the PHX, and sent to the advanced CT.

As backup to the air separation unit, a liquid nitrogen storage system will be provided for system purging and maintaining low temperature in the cold box. The backup liquid nitrogen system will be maintained in a cold, ready-to-start state.

The air separation unit process will not consume water and will produce only minor amounts of water from condensation in the main air compressor aftercooler. This water will be sent to IWT. The unit will require water only for noncontact cooling purposes which will be provided from the makeup water system and/or the cooling reservoir.

G. By-Product Handling

1. Slag

The slag handling system is designed to remove the slag that exits through the radiant syngas cooler sump. The slag consists of the coal ash and unconverted coal components (primarily carbon) that form in the gasifier.

Coarse solids and some of the fine solids flow by gravity from the radiant syngas cooler sump into the lockhopper. The lockhopper acts as a clarifier, separating solid from water. When the solids collection time is over, the lockhopper is isolated from the radiant cooler sump and depressured. After that the solids are water flushed into the slag sump tank. After a preset time, the water flush is discontinued and the lockhopper is filled with water and repressured. The next collection period begins when the inlet valve is opened for a new cycle.

Solids flushed to the slag sump tank enter the tank in the section that houses the drag conveyor. in this section the solids settle onto the moving drag conveyor and are carried out of the sump. The drag conveyor discharge onto the slag screen when solids are dewatered. The slag is then transported by slag conveyors to trucks or the on-site temporary storage area.

Again, all waters produced in this slag handling system are collected and routed to the black water handling system for reuse.

This system will generate the coarse slag material at a maximum rate of approximately 210 short-tons per day (stpd) on a dry basis. The slag is classified as nonhazardous and nonleachable and will be marketed and sold for various offsite commercial uses such as abrasives, roof material, industrial filler, concrete aggregate, or road base material.

2. Slag Storage Area

During periods when the slag by-product cannot be sold in a timely manner, a temporary storage area will be developed on the site. Initially, an area will be developed to be capable of storing slag generated by approximately 2-1/2 years of operation of the IGCC unit at full capacity. An additional 2-1/2 year storage area will be developed as needed in the unexpected event that sales of the slag for offsite uses are less than the slag production rates. The temporary slag storage area would provide sufficient capacity for developing storage cells for up to five years of slag production from the IGCC unit operating at 100-percent capacity. The slag storage area will include a stormwater runoff collection basin and surrounding berm to prevent runoff from reentering the area. Both the slag storage area and the runoff collection basin will be lined with a synthetic material or other materials with similar low permeability characteristics. The runoff basin will be designed to contain runoff water volumes equivalent to 1.5 times the 25-year, 24-hour storm event. Water collected in the runoff basin will be routed to the industrial wastewater treatment (IWT) system for filtration.

H. Sulfuric Acid Plant

In the sulfuric acid plant, the sulfur-containing acid gases from the hot and cold gas cleanup systems are converted to sulfuric acid for sale to the local Florida fertilizer industry. The conversion of acid gases involves a multi-step catalytic process.

In the HGCU process, an acid gas is produced which has a high SO_2 concentration. In the CGCU process, hydrogen sulfide (H_2S) containing gases from the acid gas removal unit and the NH_3 stripping unit will be routed through knockout drums to remove any entrained water. The CGCU gases will then be introduced into the decomposition furnace, along with combustion air. Supplemental fuel may be added to maintain the proper operating temperature. The air may be preheated to reduce the volume of fuel and thereby combustion products. Hot gases from the HGCU unit will be introduced into the system downstream of the decomposition furnace and mix with the combusted acid gas from the CGCU unit.

The mixed gases from the CGCU and HGCU systems will be cooled in a waste heat boiler, recovering as much usable energy as possible. The boiler steam side will operate at 400 psig to avoid condensing acid in the tubes. The gases from the waste heat boiler will be cooled in a quench tower with a circulating stream of weak acid, i.e., a conventional open spray tower. The gas then flows through the gas cooling tower, a packed column, for further cooling and water condensation.

Reaction air in the form of low-pressure 95% purity oxygen will be added to the process stream to provide the required amount of oxygen for the SO_2 to SO_3 conversion.

The gases leaving the cleaning and cooling system will flow to a drying tower, where the remaining water is removed. The gases from the drying tower will go to the main blower, which provides the necessary pressure for flow through the reactor beds and absorber towers.

The gases from the blower will then be heated in the reactor feed/effluent exchangers to achieve the proper reaction temperature and sent through catalytic reactor beds. There will be additional heat removal and recovery equipment in the reactor section between the reactor beds. An indirect propane-fired heater will be used to supplement the reaction heat for startup. The gases from the reactor will be cooled and sent to the absorber towers, where 98-percent acid absorbs the SO_3 from the process gas stream. The high concentration H_2SO_4 will be circulated from the absorber towers bottoms, through the acid coolers, and then returned to the top of the absorber towers. The gases from the absorber towers will pass through mist eliminators to remove acid mist, and the gas from the final absorber tower will then be vented to atmosphere.

The H_2SO_4 unit will be located adjacent to the gasification facilities on the site. The facilities will include an aboveground tank to provide for 5 days of temporary storage of the H_2SO_4 by-product and appropriate handling and loading equipment. The H_2SO_4 will be transported offsite in specially designed rail cars or trucks for commercial use.

Stormwater runoff from the H_2SO_4 storage, handling, and loading area will be directed to the IWT system for appropriate treatment prior to being routed to the cooling reservoir for reuse.

I. Balance of Plant Systems

1. Cooling Water

The steam electric generating components of the IGCC unit require water to cool or condense the exhaust steam from the steam turbine. Cooling water is also required for gasification, ASU, sulfuric acid, and other miscellaneous users. The waste heat transferred to the cooling water must then be rejected to the atmosphere. The cooling/heat rejection system for the Polk Power Station will be a cooling reservoir.

The cooling reservoir will be constructed in areas which have been mined for phosphate and currently consist of water-filled mine cuts between rows of overburden spoil piles. The reservoir will occupy an area of approximately 860 acres, including the areas of the surrounding and internal earthen berms. The reservoir will be a primarily below-grade facility after final contouring and development of the site.

Intake and discharge structures to provide and subsequently discharge the cooling water will be constructed within the cooling reservoir. The estimated circulating cooling water flow requirements are approximately 130,000 gpm for the steam turbine condenser and 40,000 gpm for the remainder of the plant including the air separation unit. One set of two 50 percent pumps will supply water for the condenser, and another set of two 50 percent pumps will supply water for the other users. This warmed return water will be routed throughout the reservoir area by the internal berm system and cooled through evaporation prior to intake and reuse in the system.

For users that require higher quality water than that provided by the cooling reservoir, two closed loop cooling water systems are provided: one for the power generation area and one for the gasification area. Heat is rejected from these loops to the reservoir cooling water.

2. Fuel Oil Storage

The plant has storage for 3,000,000 gallons of No. 2 fuel oil, which is used to fire the auxiliary boiler and the combustion turbine when gasification is down.

Fuel oil is unloaded from the tank trucks and pumped by the fuel oil truck unloading pumps to the fuel oil storage tank. From the fuel oil storage tank, the fuel oil is pumped to either the combustion turbine fuel forwarding skid or to the auxiliary boiler.

The unloading area is curbed and the storage tank area is diked. All rainfall and spills in these areas are collected and sent to an oily-water separation system.

VI. PROJECT MANAGEMENT

An integrated team style of management has been incorporated into the Polk IGCC Project since its inception.

Tampa Electric's assumption of the Cooperative Agreement with DOE to build this IGCC Demonstration facility incorporates the management of the DOE portion of the Project by TECO Power Services, Inc., a TECO Energy, Inc. subsidiary and affiliate to Tampa Electric Company.

Early in the project, the decision was made to form and periodically convene a Technical Advisory Committee (TAC) comprised of representatives from organizations on the leading edge of gasification technology and operating experience. Members include Texaco, General Electric Company, Bechtel Power Corporation, Electric Power Research Institute (EPRI), Southern California Edison (Coolwater Plant experience), Tennessee Eastman Division of Eastman Chemical Company, TECO Power Services, Inc., and Tampa Electric Company. This group met three times in 1993, on 4/29, on 6/23 and 9/1, and recommendations from this group have contributed to improvements in the areas of plant design, plant layout, equipment selection and configurations, sparing philosophies, safety considerations, reliability analysis, training requirements, start-up sequencing, and others too numerous to mention. The TAC has proven to be a valuable asset to the Project and will continue to meet on an as-needed basis throughout the project.

When the contract for detailed engineering of the project was signed, Tampa Electric and Bechtel decided to create an integrated team within the Bechtel offices in Houston to utilize the extensive coal-fired power plant experience and the overall engineering and procurement expertise within Tampa Electric Company to enhance the quality and responsiveness of the Houston-based teams for engineering and procurement. The key individuals selected and translocated to Houston included TEC's Engineering Project Manager, lead discipline-level engineers, Construction Manager, Procurement Manager, Major Contracts administrator, and procurement specialists, and an EPRI representative on loan to TEC for the Project. This working arrangement has been very effective and has enhanced the flow of critical information among the various groups.

In addition, Alignment Meetings have been held with various groups; such as, Tampa Electric and Bechtel key project personnel, Corporate Sponsors and Project Management representatives of the major project participants, and Engineering and Construction Managers with their key discipline-level personnel. These sessions have helped the teams bring focus to the critical success factors needed to make the Polk IGCC Project a technical and commercial success for all participants and for the electric utility industry.

To expedite the decision-making process in the highly fluid design environment of this project, procedures have been modified to empower key individuals within Tampa Electric Company to make decisions necessary to prevent costly delays and rework. In an evolving technology such as IGCC, it is important to maintain control of project cost and schedule, and TEC and TPS will continue to review policies and procedures to maintain the flexibility required for a project of this type.

We fully expect the project management style developed for this project to be a model for IGCC projects of the future.

VII. PROJECT COSTS

Information in this section includes references to the August '93 Total Installed Cost (TIC) Estimate with a brief explanation of the basis for this Estimate, Project *Costs and DOE Funding for the Year 1993, Project Costs and DOE Funding for Budget* Period 1 (BP1) ending December '93, and approved Budget Period 2 (BP2) DOE Funding and Total Project Cost Estimate.

A. August 1993 TIC Estimate: The purpose of this estimate is to have a basis for cost control activities and account for DOE funding for the Project through Budget Period 2, and this estimate will be used as the basis for Total Installed Cost incentives in the contracts with Bechtel Power Corporation. The TIC Estimate includes all costs regardless of the source of funding.

The TIC Estimate is based entirely on the Texaco Preliminary Engineering Package with the exception of the open loop circulating water pumps and the closed loop cooling water pumps which were downsized. The estimating effort concentrated on the scope and pricing of major equipment. The values for all remaining direct materials were estimated in the following manner:

* <u>Process Areas:</u> *factored as a ratio of major equipment costs based on* Coolwater experience and standard Bechtel factors.
* <u>Power Generation:</u> detailed estimate based on Crockett and Standard Plant which was converted to factors for consistency with process areas.
* <u>Site Preparation:</u> detailed estimate based on estimated quantities, unit rates, and execution plan / schedule.

See **<u>Exhibit A</u>** in the Appendix of this report for details by plant area of the Current BP2 TIC Project Estimate.

B. Total Project Costs expended during the calendar year 1993 were $72,454,018. Procurement of long lead items (Gasification Vessels, GE Engineered Equipment Package, Air Separation Unit) account for the majority of 1993 IGCC costs. Preliminary engineering and land purchases account for another $31,500,000 of the 1993 costs. DOE cost shared ($11,808,628) of the 1993 expenses.

See **<u>Exhibit B</u>** for details of the 1993 Year to Date (YTD) Actual Expenses (through December 1993) listed by Expenditure Type.

Total Project to Date (PTD) Actual Costs through December 1993 were $87,422,618 with DOE having cost shared ($15,550,000) of that amount.

See **<u>Exhibit C</u>** for details of the Project to Date Actual Expenses through 1993. This period ending in 1993 coincides with DOE Budget Period 1.

C. On October 22, 1993, TEC requested approval from DOE in the Continuation Application to proceed into Budget Period 2 and obligate $94,703,253 to be cost shared against a BP2 Project Budget of $472,455,244.

See **Exhibit D** for details of the BP2 Budget.

Included in this estimate was a cost growth to the project of $35,771,157 of which DOE will provide funding of ($9,624,222).

See **Exhibit E** for details of the Project Cost Estimate Comparison between BP1 and BP2.

The Continuation Application to proceed into BP2 was approved on December 23, 1993. Approval to proceed into BP2 will not include any cost sharing related to construction activities until the DOE issues a Record Of Decision (ROD) on the final Environmental Impact Statement (EIS) which provides for full funding of BP2.

VIII. TECHNICAL PROGRESS

The Technical Progress Section of the report is divided into subsections which individually address the specific categories of Detailed Engineering, Procurement and Significant Enhancements, in that order. These subsections then list accomplishments for the various IGCC plant areas, from Coal Delivery through Power Generation and the processing of by-products.

A. DETAILED ENGINEERING

1. Coal Delivery, Handling and Storage Facilities:

* Preparation and issuance of Process Flow Diagrams (PFD's) for design based on the original design concept (subsequently enhanced).
* Preparation and issuance of Piping and Instrument Diagrams (P&ID's) for review based on the original design concept, and revision and re-issuance reflecting the revised design case.
* Preparation and issuance of the Area Plot Plan for review based on the original design concept and revision and re-issuance reflecting the revised design.
* Preparation and issuance of Area Electrical One Line Diagrams for review.
* Preparation and issuance of system technical specifications for quote and preparation of technical bid evaluation.
* Evaluation of the original coal handling system design and redesign of this system to eliminate rail delivery and open coal field storage concept and, instead, provide a truck-based delivery system and storage silo facilities.

2. Coal Grinding and Slurry Preparation:

* Complete review of the Texaco Preliminary Engineering Package (PEP).
* Preparation and issuance of PFD's for design.
* Preparation and issuance of P&ID's for review.
* Preparation and issuance of Area Plot Plans for review.
* Preparation and issuance of Area Electrical One Line Diagrams for review.
* Preparation and issuance of Area Electrical Classification Drawings for review.

3. **Gasifier System:**

* Monthly engineering interface meetings with syngas cooler vendors (MAN GHH and Steinmuller).
* Complete review of the Texaco PEP.
* Review of MAN GHH and Steinmuller contracts for consistency with Project technical requirements.
* Preparation and issuance of PFD's for design.
* Preparation and issuance of Equipment Process Datasheets for design.
* Preparation and issuance of P&ID's for HAZOP review.
* HAZOP review of P&ID's.
* Preparation and issuance of Area Plot Plans for review.
* Preparation and issuance of Area Electrical One Line Diagrams for review.
* Preparation and issuance of Area Electrical Classifications for review.
* Review of MAN GHH and Steinmuller syngas cooler flow and temperature models.
* Study of Texaco Brine Concentration package and other process alternates.
* Study of nitrogen requirements for the entire facility and comparison against APCI's contractual basis for the ASU.

4. **Hot Gas Clean Up System:**

* Preparation and issuance of Area Plot Plans for review.
* Incorporation of HGCU process and utility requirements into the Gasification area Heat and Material Balances.
* Engineering "Kick Off" meeting conducted at GEESI's facility.
* Preparation and issuance of Sodium Bicarbonate Injection System equipment package for review.
* Preparation and issuance of Regenerator Gas Heater equipment package for review.
* Preparation and issuance of Start Up Heater equipment package for review.
* Preparation and issuance of Fines Separator equipment package for review.
* Preparation and issuance of vessel design drawings for Absorber Inlet and Outlet Lockhoppers, Regenerator Outlet Lockhopper and Sorbent Make-Up Silo.
* Preparation and issuance of vessel design drawings for Regenerator Sorbent Bin, Run and Charge Lockhoppers, Secondary Cyclone Lockhopper, Barrier Filter Lockhopper, Regenerator, Absorber, Primary Cyclone and Secondary Cyclone.
* Preparation and issuance of P&ID's for review.
* Preparation and issuance of Control Concept for review.
* Preparation and issuance of Facility General Arrangement drawings for review.
* Preparation and issuance of Instrument Data Sheets for review.
* Preparation and issuance of Control Valve Data Sheets for review.

5. Cold Gas Clean Up System:

* Preparation and issuance of PFD's for design.
* Preparation and issuance of P&ID's for HAZOP.
* HAZOP review of P&ID's and incorporation of HAZOP comments with issuance of P&ID's for design.
* Preparation and issuance of Area Plot Plan for review.
* Preparation and issuance of Logic Diagrams for review.
* Preparation and issuance of Area Electrical One Line Diagrams for review.
* Preparation and issuance of technical specifications for major equipment for quote, preparation of technical bid evaluations and updating of the specifications for purchase.
* Evaluation of original system design, and redesign of the system based on a less conservative H2S to COS ratio.

6. Sulfuric Acid Plant:

* Evaluation of original sulfur recovery design concept based on production of both elemental sulfur and sulfuric acid, and development of a new design based on sulfuric acid production only.
* Preparation and issuance of Sulfuric Acid Plant Technical Specification.

7. Combined Cycle Power Generation System:

* Review of GE Engineered Equipment Package.
* Preparation of Simple Cycle grouping document, including List of Equipment, P&ID's and Specifications.
* Issuance of Site Conditions Specification.
* Design Review Meetings conducted with GE.
* Development of overall plant steam balance.
* Design Coordination Meetings conducted to review P&ID's with GE.
* Review with GE of the process design change to go from Sulfur Plant to Sulfuric Acid Plant. Result was improvements in both output and heat rate.
* Preparation and issuance of Area Plot Plan for design.
* Optimization of condenser cooling system to establish design parameters for condenser and circulating water pumps.
* Review of process and auxiliary P&ID's for Operability and Safety considerations.
* Incorporation of comments from Operability and Safety Review and issuance of process P&ID's for design.
* Initiation of 3D model planning for Power Block.
* Initiation of design for major foundations.

* Preparation and issuance of Area Electrical Classification for design.
* Development of specifications for Substations, Uninterruptible Power Supply System and 230KV Dead-End Structures.

8. Air Separation Unit

* Preparation and issuance of Heat and Material Balances.
* Preparation and issuance of PFD's.
* Preparation and issuance of P&ID's.

9. By-Product Handling Systems:

* Preparation and issuance of PFD's for design.
* Preparation and issuance of P&ID's for review.
* Preparation and issuance of Area Plot Plan for review.
* Definition of design requirements and development of design concept for brine and HGCU solids disposal areas.

10. Cooling/Circulating Water and Firewater Systems:

* Preparation and issuance of PFD's for design.
* Preparation and issuance of P&ID's for HAZOP.
* HAZOP review of P&ID's and incorporation of HAZOP comments with issuance of P&ID's for design.
* Preparation and issuance of Area Plot Plan for design.
* Preparation and issuance of Area Electrical One Line Diagrams for review.
* Preparation and issuance of technical specifications for major equipment for quote, preparation of technical bid evaluations, and updating of specifications for purchase.
* Onsite testing of cooling reservoir water quality and evaluation of test results.

11. Power Block Closed Loop Cooling Water System:

* Evaluation of various cooling options and optimization of the cooling systems for the power block.
* HAZOP review of P&ID's and incorporation of HAZOP comments with issuance of P&ID's for design.

12. **Fuel Oil Storage:**

* HAZOP review of P&ID's and incorporation of HAZOP comments with issuance of P&ID's for design.

13. **Compressed Air System:**

* HAZOP review of P&ID's and incorporation of HAZOP comments with issuance of P&ID's for design.

14. **Water Treatment System:**

* Preparation and issuance of PFD's for design.
* Preparation and issuance of P&ID's through HAZOP revision.
* Preparation and issuance of Area Plot Plan for review.
* Preparation and issuance of Area Electrical Classification for review.
* Preparation and issuance of Area Electrical One Line Diagrams for review.
* Preparation and issuance of system equipment technical specifications for quote, preparation of technical bid evaluations, and updating of specifications for purchase.

15. **Waste Treatment System:**

* Redesign of the waste treatment system to eliminate coal pile runoff treatment facilities.
* Preparation and issuance of PFD's for design.
* Preparation and issuance of P&ID's through HAZOP revision.
* Preparation and issuance of Area Plot Plan for review.
* Preparation and issuance of system equipment technical specifications for quote, preparation of technical bid evaluations and updating of specifications for purchase.

B. PROCUREMENT:

1. Coal Delivery, Handling and Storage Facilities:

* Preparation and issuance of system purchase requisition for quotation.

2. Coal Grinding and Slurry Preparation:

* No procurement activity in 1993.

3. Gasifier System:

* Issuance of purchase order for radiant syngas cooling system.
* Issuance of purchase order for convective syngas cooling system.
* Issuance of purchase order for shop fabricated vessels.

4. Hot Gas Clean Up System:

* No procurement activity in 1993.

5. Cold Gas Clean Up System:

* Preparation and issuance of major equipment purchase requisitions for quotation and preparation of commercial bid evaluations.

6. Sulfuric Acid Plant:

* Issuance of Sulfuric Acid Plant subcontract for quotation.

7. **Combined Cycle Power Generation System:**

* Placement of purchase orders for Shop Fabricated Vessels and Turbine Bridge Crane.
* Receipt of all necessary approvals to purchase DCS System.
* Preparation and submittal of technical and commercial evaluations for approval to purchase.
  - Auxiliary Boiler
  - Large Transformers
  - Generator Breaker Switches
  - Iso-Phase Bus Duct
  - Condensate Storage Tank
  - Rotary Pumps
* Preparation and issuance of inspection plans for all major equipment.

8. **Air Separation Unit:**

* Issuance of purchase orders for Main Air Compressor, Oxygen Compressor, Nitrogen Compressor and Nitrogen Booster Compressor.
* Issuance of purchase orders for High Pressure and Low Pressure Columns.

9. **By-Product Handling Systems:**

* No procurement activity in 1993.

10. **Cooling/Circulating Water and Firewater Systems:**

* Preparation and issuance of major equipment purchase requisitions for quote and preparation of commercial bid evaluations.

11. **Power Block Closed Loop Cooling Water System:**

* Technical evaluation of bids for Cooling Water Heat Exchangers.

12. **Fuel Oil Storage:**

* Issuance of purchase orders for Fuel Oil Unloading Station, Fuel Oil Pumps and Fuel Oil Storage Tank.

13. Compressed Air System:

* Issuance of purchase orders for Instrument Air Dryer and Air Receivers.
* Technical bid evaluations for Plant and Instrument Air Compressors.

14. Water Treatment System:

* Preparation and issuance of system equipment purchase requisition for quote, preparation of commercial bid evaluation, and issuance of purchase order.

15. Waste Treatment System:

* Preparation and issuance of system equipment purchase requisition for quote and preparation of commercial bid evaluation.

C. SIGNIFICANT ENHANCEMENTS

1. Coal Delivery, Handling and Storage Facilities:

* The original design concept for the coal handling system provided for delivery of coal by rail or truck. The system consisted of a rail loop, a below ground unloading hopper, a 45 day inactive storage field, and an open reclaim pile. the open storage facilities required collection and treatment of both the storm water runoff and leachate from the coal field. Transportation studies by Tampa Electric Company determined that for the foreseeable future the use of their existing Big Bend coal field for storage and delivery of coal by truck to the Polk site was more economical than the original concept.

The redesigned system consists of an above ground truck unloading facility with two (2) 5000 ton capacity storage silos. Coal from the silos is fed directly to the coal grinding facility.

The redesigned system eliminated the open coal field and its lining and leachate system and the waste collection and treatment facilities required to treat the water from this area. These changes resulted in a substantial reduction in capital cost for the facility, a reduction in fugitive dust emissions, and a reduction in operating cost.

2. Coal Grinding and Slurry Preparation:

* The original equipment arrangement for this area was reconfigured to achieve significant reductions in the quantities of required piping material and structural steel as well as reduced construction costs and piping system pressure drops.

* The coal grinding and slurry preparation system sizing basis was reconfigured from two 50 percent trains to two 60 percent trains to allow for increased onstream time due to required pump repairs and to provide more rapid recharging of slurry tanks following a pump outage.

* Due to consistent reports of the high reliability to be expected from the slurry feed pumps selected for PPS-1, one of the two installed pumps was deleted from this arrangement, resulting in significant capital cost savings with minimal impact to overall plant availability.

3. Gasifier System:

* The original equipment arrangement for this area was reconfigured to achieve significant reductions in the required quantities of piping and structural steel, and reduced construction costs and piping system pressure drops.

* Deletion of the RSC Quench By-Pass mode from the Gasification System resulted in significant capital and construction cost savings.

* The reconfiguration of the Fines Handling System from a batch plate press system to a continuous rotary drum system resulted in cost savings as well as simplification of operation and reduced maintenance requirements.

* The Grey Water System metallurgy was reviewed and upgraded to meet expected chloride levels.

* The Gasifier structure was reconfigured to add the capability for lifting of the Gasifier and the head of the RSC for tube repairs, allowing for reduced downtime for repairs.

* Piping transition pieces in the Convective Syngas Cooling System were reconfigured to reduce the risk of pluggage and to optimize the syngas feed temperature to HGCU.

* The Slag Handling System was reconfigured to eliminate the originally recommended high maintenance type of drag chain conveyor system and, instead, go to a much simpler piped system. This change is expected to result in significant cost savings, substantially reduced maintenance and higher reliability.

* The Grey Water System configuration was reviewed with regard to expected flows during system upsets, and tankage was added to handle the expected water balance swings.

* Manways were added to the RSC head to allow access to the tube cage where no access previously existed.

* Lockhopper valves within the Gasification System were standardized in size to reduce the cost of spares.

4. **Hot Gas Clean Up System:**

* The depressurization system for HGCU vessels was reconfigured to implement a vent and purge gas system to allow "offgas" streams to be sent to a Thermal Oxidizer for regulatory permit compliance.

* A review was conducted and enhancements recommended for the handling of high temperature fines by-products.

5. **Cold Gas Clean Up System:**

* The original design concept for the acid gas removal system was based on a very conservative H2S to COS ratio. Gasification experience has shown that the expected ratio is considerably higher than this, and that an adequate design can be achieved which results in capital savings in both the acid gas removal system and the sulfuric acid plant. Design was changed to incorporate these improvements.

6. **Sulfuric Acid Plant:**

* The original design concept for sulfur recovery consisted of a Sulfur Plant for the "offgas" from CGCU and a Sulfuric Acid Plant for the "offgas" from HGCU. The Sulfur Plant was eliminated in favor of a full capacity Sulfuric Acid Plant to handle the "offgas" from both units. This change resulted in a capital cost savings and a savings in operating cost, and provides a by-product which is readily saleable to the West Central Florida phosphate industry.

7. Combined Cycle Power Generation System:

* The requirement for Simple Cycle operation of the Combustion Turbine-Generator in July of 1995 was removed following review of projections of TEC's power requirements and system capability. This change allowed the elimination of the Simple Cycle Stack, the associated transition ducting and special foundation requirements, and miscellaneous other issues, resulting in reduced capital cost and simplification of construction sequencing for the power block area.

* Auxiliary plant cooling water systems were separated from the Circulating Water System, resulting in reduced plant parasitic power consumption due to the lower head requirements for the circulating water pumps.

* The potential for gas side corrosion of the Low Pressure Economizer tubes was investigated, and parameters were developed to define the LP Economizer Recirculation Pump requirements.

8. Air Separation Unit:

* A liquid nitrogen storage tank and vaporization system was added to provide backup nitrogen for the plant nitrogen blanketing system as well as for ASU purge requirements. This change will improve nitrogen blanketing system reliability.

* The front end adsorption system was redesigned to improve operating flexibility and to improve oxygen production capability at design conditions.

* A dedicated 60 MVA 230KV/13.8KV power transformer was added to the plant's high voltage electrical configuration to improve power system reliability and efficiency related to the starting requirements for the main air compressor and nitrogen compressor, and to reduce capital cost.

9. Power Block Closed Loop Cooling Water System:

* Heat exchangers within this system were changed from shell and tube design to plate and frame design, resulting in significant savings in cost and plot space. This change also provides the flexibility to increase heat transfer surface areas within these heat exchangers in the future, if necessary, without major changes to equipment or piping.

10. Compressed Air System:

* Enhancements were made to this system to improve reliability and availability. These include the provision of separate compressed air receivers for the plant service air and instrument air systems, reducing the size of the air receivers, increasing the size of the compressors, and changing the compressor type from reciprocating to rotary.

11. Waste Treatment System:

* The previously noted modification to the Coal Handling System which eliminated the open coal field also allows for deletion of the Coal Pile Runoff Treatment Package and the Sludge Landfill area. The remaining process waste treatment facilities consist of an equalization basin, an oily water separation and recovery system, and a filter. The packaged Sanitary Waste Treatment Package remains unchanged.

IX. CONSTRUCTION MANAGEMENT

Construction Management activities during 1993 focused on a number of key areas including:

* Review of existing major contracts.
* Familiarization with existing environmental documents and with future requirements to ensure compliance at all levels.
* Development of preferred contracting strategies for construction.
* Coordination with the ongoing engineering activities.
* Schedule review and integration with engineering and procurement needs.
* Input into project cost estimates.
* Development of key construction management policies and procedures to be used throughout the project.
* Selection of key members of the Construction Management Team.
* Preparation of guidelines for the Constructability Program which is expected to yield substantial savings to the total project cost.

The relatively early award of the Construction Management Services contract for this Project was made in recognition of the complexity and first-of-a-kind nature of this IGCC demonstration unit, and is expected to result in substantial savings in construction cost and time of performance. These savings will come in the form of optimized construction contract strategies, close coordination of heavy haul transportation requirements, shared use of large cranes and related construction equipment, well-planned and executed warehousing and site storage strategies, and, most importantly, up front involvement of Construction and Start-Up Management Teams with the Engineering and Procurement processes.

X. TECHNICAL PAPERS/CONFERENCE PRESENTATIONS

During 1993, Tampa Electric and TPS Project Management representatives attended major IGCC conferences and delivered technical papers related to the status of the Polk IGCC Project and to the advancement of IGCC Technology in Utility Applications. Below is a brief summary of key conferences attended and technical papers delivered.

April: At the 55th Annual Meeting of the American Power Conference held in Chicago, Illinois, sponsored by the Illinois Institute of Technology, Steve Jenkins of TPS and Deputy Project Manager for the Polk IGCC Project delivered a paper entitled "Status of Tampa Electric Company IGCC Project".

June: At DOE's Morgantown Energy Technology Center (METC) in Morgantown, West Virginia, Charles R. Black, Vice President - Project Management for Tampa Electric Company's Polk IGCC Project, delivered his paper entitled "A Utility's Perspective on the Commercialization of Gasification Power Plants".

June 28-30: Participation in the "Coal-Fired Power Systems 93 -- Advances in IGCC and PFBC Review Meeting" sponsored by the DOE Office of Fossil Energy and held at their Morgantown Energy Technology Center (METC) in Morgantown, West Virginia.

September 7-9: At the Second Annual Clean Coal Technology Conference held in Atlanta, Georgia, co-sponsored by the U.S. Department of Energy and the Southern States Energy Board, two papers were delivered by Steve Jenkins, noted above. Don Pless, Director of Advanced Technology for TPS and Project Manager for the Polk IGCC Project, authored a paper entitled "Tampa Electric Company Integrated Gasification Combined Cycle System", and Steve Jenkins delivered his paper entitled "Status of Tampa Electric Company IGCC Project" as well.

October 27-29: At the Twelfth EPRI Conference on Gasification Power Plants held in San Francisco, California and sponsored by the Electric Power Research Institute, Charles R. Black, noted above, delivered his paper entitled "Tampa Electric's 250MW IGCC Project Status".

In addition to these presentations to key members of the Utility Industry, several other presentations have been made to groups of community and business leaders at various stages of the Project. The TEC/TPS Project Management Team strives to maintain and enhance Tampa Electric Company's excellent reputation as a strong and supportive Corporate Citizen by communicating with such groups as well as with the residents of the area surrounding the Polk Power Station Site to keep them well informed of the progress of the Project as well as of the benefits this project will bring to their communities. The Team continues to educate these groups about the advantages of successful IGCC application to the Electric Utility Industry and about the advantages of this IGCC technology for U.S. domestic fuel reliability.

XI. PROJECTIONS FOR 1994

1994 is expected to begin with Certification of the Polk Power Station Site by the Florida Governor and Cabinet in January, followed closely by other critical State and Federal environmental permitting processes and approvals.

Site Development activities will commence in earnest to prepare the Site for the installation of underground utilities, equipment foundations and structural steel erection.

Preliminary Engineering activities will be completed early in 1994. Detailed Engineering will commence early in the year and near completion by year's end.

Key contracts will be let for the following services/equipment:

1) HGCU Detailed Engineering and Start Up Support.
2) Site Development.
3) Turnkey Sulfuric Acid Plant.
4) Emergency Shutdown System.
5) Brine Concentration System.
6) Heavy Haul Transportation.
7) Coal Transportation.
8) By-Product Sales.
9) Major Equipment Procurements.
10) Major Construction Package Contract.

Staffing plans will be developed along with Training Program requirements and schedules. Key plant Operations and Management leadership positions will be filled, and selection criteria established for the plant's operating personnel.

Start Up procedures, and planning and sequencing schedules will be developed.

Operability reviews and HAZOP reviews will be conducted on all systems with input from these reviews to be factored into equipment and facility designs.

The 3D Model for the plant will be developed and utilized along with Planning Studies to conduct Walk-Through reviews of all major plant areas to identify and eliminate piping and structural steel interferences.

HGCU Pilot Plant Testing will continue at GE's Corporate Research and Development (CR&D) facility in Schenectady, N.Y. to refine the design of major vessels and processes, to test sorbent performance and to test the effectiveness of the sodium bicarbonate injection system.

GE's Test Program at the Combustion Laboratory in Schenectady, N.Y. will continue throughout most of 1994 to complete the design and testing of combustion hardware for Polk Power Station's first-of-a-kind GE 7F combustors fired on syngas with head-end nitrogen injection.

Major equipment for the IGCC facility will be fabricated at key facilities throughout North America and Europe.

And activities will shift to the Site as the Polk IGCC Project begins to take shape and substance on its road to the Successful Demonstration of IGCC Technology incorporating Hot Gas Clean Up in this State-of-the-Art Commercial Scale Utility Power Generation Application.

XII. SUMMARY

Progress in 1993 has been good on all fronts. Major strides have been reached in the Environmental arena, in the completion of Preliminary Design efforts, in the early commitments for long lead items like the Gasification and Syngas Cooling Systems, the Combined Cycle Power Generation Equipment, the Air Separation Unit and others. Technical Services Agreements are in place to provide guidance and expertise as we move forward with design.

Excellent progress has been made in the efforts to control Cost and Schedule. Approval of DOE Funding for Budget Period 2 is a significant accomplishment.

Key Tampa Electric Management, Engineering, Construction, and Operations Team Members have been selected to see the Polk IGCC Project through to its completion and beyond.

This Clean Coal Technology Demonstration Project will set the standard for IGCC plants of the future. The design integration efforts amongst the major participants continue to produce sound results and the promise of an effective and efficient blending of the complex Gasification and Combined Cycle Technologies.

Tampa Electric Company has assembled, and continues to build upon, what we believe to be the most capable and experienced team of Major Project Participants in their respective areas of expertise available for a project of this type. We have solicited the advice of some of the most knowledgable firms and people in the fields of Gasification and Combined Cycle Technologies through the Technical Advisory Committee assembled in early 1993. And we are convinced that the integration of the particular processes and equipment that have been carefully selected and blended together to become the Polk Power Station Unit 1 IGCC Facility is the best configuration available today to successfully demonstrate this IGCC Technology in this Electric Power Generation Application.

The steps taken during 1993 to secure contracts for major equipment systems, engineering, procurement and construction management services, and technical advice have been supported in full measure by the Senior Management of Tampa Electric Company and of its Holding Company, TECO Energy, Inc. as well as by DOE and all of the Project Major Participants selected to date.

In our Alignment Sessions, the Polk Project Team has acknowledged the significance of this Project to the U.S. Coal Industry, to the Environmental Communities, to the Electric Utility Industry, the Refinery Industry and, perhaps most importantly, to the United States Government.

We firmly believe that this Polk IGCC Demonstration Project, as configured, supports and fulfills the intent of the Cooperative Agreement between Tampa Electric Company and the U.S. Department of Energy, and will provide the results expected.

1994 will bring Groundbreaking for the Polk IGCC Facility, fabrication of the major equipment, the completion of Detailed Engineering and the beginning of Construction. Tampa Electric Company and its affiliates and partners in this most important project are proud to be on the leading edge of the mission to develop IGCC Technology for the future.

XIII. APPENDIX

A. **Exhibit A** - Total Installed Cost Estimate - August 1993

B. **Exhibit B** - Year End 1993 Total Project Costs

C. **Exhibit C** - Project to Date Actual Costs Through 1993

D. **Exhibit D** - Project Cost Estimate for Budget Period 2 Expenditures

E. **Exhibit E** - Total Project Cost Estimate Comparisons - BP1 vs. BP2

EXHIBIT A

POLK POWER STATION
CURRENT BP2 TIC PROJECT ESTIMATE

($ x 1,000)

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	(1) TOTAL 1992	(2) TOTAL 1993	(3) TOTAL 1994	(4) TOTAL 1995	(5) TOTAL 1996	(6) = (1 .. 5) PROJECT TOTAL
IGCC FACILITY						
H.G.C.U.			350	14,199	969	15,518
SULFURIC ACID PLANT			3,243	13,845	3,600	20,689
C.G.C.U.			336	10,917	1,810	13,063
GASIFICATION, ASU & LICENSE FEES	2,870	12,143	24,739	99,089	19,307	158,148
POWER BLOCK	1,560	37,952	37,764	42,788	7,716	127,780
BALANCE OF PLANT	0	0	10,468	49,786	4,206	64,461
SUBTOTAL IGCC FACILITY	4,430	50,095	76,900	230,625	37,609	399,659
ENGINEERING & CM	3,294	12,893	22,559	8,262	4,867	51,875
SITEWORK ENGR & CONSTRUCTION	177	262	18,018	19,654	1,389	39,500
OWNERS COSTS						
TECO INTERNAL	1,574	3,881	6,096	8,608	7,617	27,776
CAPITALIZED INVENTORY & FUEL				390	840	1,230
LAND ACQUISITION COSTS		19,943				19,943
PERMITTING & LEGAL COSTS	1,498	1,249	285	49	40	3,121
PREVIOUS COSTS	7,737	0	0	0	0	7,737
SUBTOTAL OWNERS COSTS	10,809	25,073	6,381	9,047	8,497	59,806
TOTAL TIC ESTIMATE	18,710	88,324	123,857	267,588	52,362	550,840
DOE REIMBURSEMENT	(3,741)	(15,110)	(25,332)	(55,656)	(10,414)	(110,253)
NET TEC COSTS	14,969	73,214	98,525	211,932	41,948	440,587

EXHIBIT B

POLK POWER STATION
ACCOUNTS L50 & 105.57 PROJECT SUMMARY
YTD ACTUALS THRU 12/93

RESOURCE	YTD 12/93 T.I.C. BUDGET	YTD 12/93 ACTUAL EXPEND.	YTD 12/93 $ VARIANCE	YTD 12/93 % VARIANCE
AFUDC	0	0	0	N/A
A&G	680,179	637,411	(42,768)	-6.3%
PERMITTING (RS 03 ONLY)	655,832	554,120	(101,712)	-15.5%
EIS PERMITTING (RS 03 ONLY)	391,382	450,902	59,520	15.2%
TEXACO LICENSE (w/ IGCC)	0	0	0	N/A
LAND COSTS	19,942,888	19,862,917	(79,971)	-0.4%
SITEWORK	262,359	550,453	288,094	109.8%
TECO ENERGY	430,853	475,373	44,520	10.3%
MOBILIZATION	0	0	0	N/A
INVENTORIES	0	0	0	N/A
LEGAL	201,697	299,350	97,653	48.4%
ENGINEERING	12,893,159	11,776,685	(1,116,474)	-8.7%
IGCC FACILITIES	50,095,138	46,965,291	(3,129,847)	-6.2%
TAMPA ELECTRIC (IN-HOUSE $)	2,770,169	2,690,143	(80,026)	-2.9%
PREVIOUS COSTS	0	0	0	N/A
DOE REIMBURSEMENTS	(15,109,535)	(11,808,628)	3,300,907	-21.8%
TOTAL POLK PROJECT -->	**73,214,121**	**72,454,018**	**(760,103)**	**-1.0%**

BUDGET/CASH FLOW BASIS : APPROVED 8/93 T.I.C. PROJECT BUDGET

EXHIBIT C

POLK POWER STATION
ACCOUNT L50 & 105.57 PROJECT SUMMARY
PTD ACTUALS THRU 12/93

EXPENDITURE TYPE	PTD 12/93 REVISED BUDGET	PTD 12/93 ACTUAL EXPEND.	PTD 12/93 $ VARIANCE	PTD 12/93 % VARIANCE
AFUDC	0	0	0	N/A
A&G	1,141,264	1,098,496	(42,768)	−3.7%
PERMITTING (RS 03 ONLY)	1,995,092	1,893,380	(101,712)	−5.1%
EIS PERMITTING (RS 03 ONLY)	391,382	450,902	59,520	15.2%
TEXACO LICENSE (w/ IGCC)	0	0	0	0.0%
LAND COSTS	19,942,888	19,862,917	(79,971)	−0.4%
SITEWORK	439,530	727,624	288,094	65.5%
TECO ENERGY	816,738	861,258	44,520	5.5%
MOBILIZATION	0	0	0	N/A
INVENTORIES	0	0	0	N/A
LEGAL	360,458	458,081	97,623	27.1%
ENGINEERING	16,187,013	15,070,538	(1,116,475)	−6.9%
IGCC FACILITIES	54,525,138	51,395,291	(3,129,847)	−5.7%
TAMPA ELECTRIC (IN−HOUSE $)	3,497,189	3,417,163	(80,026)	−2.3%
PREVIOUS COSTS	7,736,966	7,736,966	0	0.0%
DOE REIMBURSEMENTS	(18,850,907)	(15,550,000)	3,300,907	−17.5%
TOTAL POLK PROJECT −−>	**88,182,751**	**87,422,618**	**(760,133)**	**−0.9%**

BUDGET/CASH FLOW BASIS : APPROVED 8/93 T.I.C. PROJECT BUDGET

EXHIBIT D

TAMPA ELECTRIC COMPANY
POLK POWER STATION
REVISED PROJECT T.I.C.

** TOTAL BP2 CAPITAL ONLY **

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TEC WBS LEVEL 2 & 3	DESCRIPTION	REVISED T.I.C. BUDGET $	DOE COST SHARE %	DOE REIMBURSE $
01	Common/Engr/PM – Project Management	40,132,911	40.1%	8,046,649
02	Common/Engr/PM – Environmental/Permit	529,508	40.1%	106,166
0.201	Common/Engr/PM – EIS Permit	293,179	100.0%	146,590
03	Common/Engr/PM – Sitework	630,585	40.1%	126,432
04	Common/Engr/PM – Construction Mgmnt.	7,819,053	40.1%	1,567,720
05	Common/Engr/PM – Spare Parts	1,230,000	40.1%	246,615
06	Common/Engr/PM – Previous TEC non IGCC		0.0%	0
07	Common/Engr/PM – TPS Previous		N/A	0
08	DOE Reimbursements	(94,703,220)	N/A	0
09	Common/Engr/PM – Operator Training	5,242,100	40.1%	1,051,041
1X	Hot Gas Cleanup Facilities	17,478,540	100.0%	8,739,270
12	Sulfuric Acid Plant	20,688,987	40.0%	4,137,797
2X	Cold Gas Cleanup Facilities	13,062,753	0.0%	0
3X	Oxygen Plant Facilities (w/ 4X)	0	40.0%	0
4X	Gasification Plant Facilities	147,012,855	40.0%	29,402,571
5X	Steam & Combustion Turbines & Fuel Oil Supply	59,493,144	40.0%	11,898,629
6X	Heat Recovery Steam Generator	33,381,309	40.0%	6,676,262
7X	Plant Electrical	18,942,992	40.0%	3,788,598
8X	Sitework & Buildings	48,663,109	40.1%	9,756,953
9X	Plant Utilities	36,263,622	40.0%	7,252,724
105.57	Land Aquisition Costs – Property Held	16,675,393	9.3%	773,705
A&G	TEC Administrative & General	4,915,204	40.1%	985,498
	TOTALS --->	**377,752,024**		**94,703,220**

PROJECTS 105.57 & L50 – EXCLUDES AFUDC

EXHIBIT E

POLK POWER STATION
ESTIMATE COMPARISONS – BP1 Vs. BP2

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	(1) INITIAL (BP1) PROJECT ESTIMATE	(2) INITIAL (BP1) D.O.E. ESTIMATE	(3) REVISED (BP2) PROJECT ESTIMATE	(4) REVISED (BP2) D.O.E. ESTIMATE	(5) = (3−1) VARIANCE PROJECT BP2 Vs. BP1	(6) = (4−2) VARIANCE D.O.E. BP2 Vs. BP1
IGCC FACILITY						
H.G.C.U.	24,042,000	12,021,000	15,518,160	7,759,080	(8,523,840)	(4,261,920)
SULFURIC ACID PLANT	0	0	20,688,987	4,137,797	20,688,987	4,137,797
C.G.C.U.	35,127,000	0	13,062,753	0	(22,064,247)	0
GASIFICATION, ASU & LICENSE FEES	149,006,000	29,801,200	158,148,148	31,629,630	9,142,148	1,828,430
POWER BLOCK	118,610,000	23,722,000	127,780,410	25,556,082	9,170,410	1,834,082
BALANCE OF PLANT	46,831,000	9,368,690	64,460,553	12,897,025	17,629,553	3,528,335
SUBTOTAL IGCC FACILITY	373,616,000	74,912,890	399,659,011	81,979,614	26,043,011	7,066,724
ENGINEERING & CM	53,529,000	10,732,564	51,874,672	11,268,832	(1,654,328)	536,268
SITEWORK ENGR & CONSTRUCTION	35,940,000	7,205,970	39,500,332	7,919,817	3,560,332	713,847
OWNERS COSTS						
TECO INTERNAL	22,328,864	4,476,380	27,775,756	5,597,814	5,446,892	1,121,434
CAPITALIZED INVENTORY & FUEL	3,700,000	741,850	1,230,000	246,615	(2,470,000)	(495,235)
LAND ACQUISITION COSTS	16,455,000	914,898	19,942,888	925,310	3,487,888	10,412
PERMITTING & LEGAL COSTS	1,755,777	352,033	3,120,852	801,680	1,365,075	449,647
PREVIOUS COSTS	7,744,679	1,292,413	7,736,966	1,513,538	(7,713)	221,125
SUBTOTAL OWNERS COSTS	51,984,320	7,777,574	59,806,462	9,084,957	7,822,142	1,307,383
TOTAL POLK POWER STATION	515,069,320	100,628,998	550,840,477	110,253,220	35,771,157	9,624,222
NET TEC COSTS		414,440,322		440,587,257		

DOE/MC/27363--3870

Tampa Electric Company Polk Power Station
Unit No. 1

DOE